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INTERIM REPORT: BIOGEOCHEMICAL STUDIES AT THE GEYSERS GEOTHERMAL AREA

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INTERIM REPORT:

BIOGEOCHEMICAL STUDIES AT THE GEYSERS GEOTHERMAL AREA

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Field research was begun in the spring of 1979 at the Geysers Geothermal Area, northeast of Santa Rosa, California. The program was directed toward quantitating the deposition of trace elements known to be contained in the cool tower drift. The prominent elements of ecological and biological significance in the cooling tower water are boron, arsenic, and mercury. Another goal in this program was to determine whether any of the cooling tower trace elements listed above had entered animal food chains and were detectable in the organs of resident mammals.

A period of intensive measurements was conducted in late June at Unit 12, a newly commissioned power unit with an output of 80-90 MWe. Earlier measurements were made in April at the time of leaf emergence in the local tree species. A pre-operational unit, Unit 15, was sampled at this time as well as Units 12, 7/8, and 9/10. This series of geothermal power units included ones in long operation, a newly operational unit, and a pre-operational unit. It is realized that although there is undoubtedly "crosstalk" between these units, the major effect of cooling tower effluent has been described as being relatively local. In late June, meteorological measurements, particle filtration, gas analysis of air, and a program of coordinated ecological measurements were made at Unit 12.

The ecological measurements consisted of the following methods:

- Phytometer methods
 - a. lichen bags
 - b. grass pots

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- Passive air samplers
 - a. cheesecloth traps

The phytometer method has been used widely by ecologists studying air pollution effects in vegetation of cities, and in the vicinity of various milling and mining operations. Often mosses are used for this purpose because large quantities of essentially clonal material can easily be collected, and the plants will live detached from a substratum if the air is not too dry. The method consists of placing a weighed amount of a moss collection, which was obtained from a contaminant-free environment in the test environment. The moss or plant collection is characterized spectrochemically before exposure to the test environment. The lichen bags used in this study were made from a collection of Usnea sp. lichen collected in a forest area east of Hopland. Approximately 7-10 grams of lichen was placed in a 1 dm x 1 dm cheesecloth bag which was held in a distended configuration with a plastic-covered wire frame. The lichen is a physiologically active plant in this phytometer as they are in their native habit as an epiphyte on oak and pine trees in this part of California. They provide large reactive surface area as well as properties of a living plant, being composed of a fungal host (the visible material) and an internal algal symbiont which carries on photosynthesis.

The grass pots were four gallon plastic greenhouse pots with a planting of barley (Hordeum vulgare). The soil and pre-exposed barley stems were analyzed to provide data on the biogeochemical background of the phytometer organism. The use of this phytometer eliminated soil uptake of cooling tower drift elements and provided only foliar complexation as the means of uptake.

Barley is known to have modest sensitivity to boron. The grass pots were maintained at Unit 12 at three locations and at Unit 7/8 in a scrub oak stand that had been severely damaged by cooling tower drift. Grass was sampled after 12-13 days of exposure.

The passive air samplers were essentially the cheesecloth and wire assemblies without the lichen in them. The use of muslin as a particulate air sampler material has received some attention in similar studies. The muslin available for this study was spectrochemically contaminated with several elements, including sulphur, probably from sizing agents. Cheesecloth was found to be quite clean and was easily made into 1 dm x 1 dm bags and stretched over the wire frames. The cheesecloth bags were hung on trees and other structures at various distances from the geothermal units and in other locations in the area to obtain data on the movement of elements released from cooling towers.

Vegetation (leaf) samples were collected at each location where a lichen bag or cheesecloth bag was placed. Other leaf samples were collected at locations within the cooling tower drift plume, and from control sites westward or upwind from the geothermal area.

Small mammals were live-trapped with Sherman traps and euthanized in the field and frozen on dry ice. Organs were excised in the lab, freeze-dried, and weighed aliquots were digested in acid in platinum crucibles. Typically the liver, kidney, brain, GI tract, muscle, and bone from the rear legs were taken from the animals.

Mammals were trapped in the study area at Unit 12, at Unit 7/8, and at Unit 9/10. Animals were also obtained from a control area west of the geothermal

area near Healdsburg, California. The species obtained were Microtus californicus, Peromyscus truei, P. maniculatus, Reithrodontomys megalotis, and Neotoma fuscipes. These animals characteristically have small home ranges with radii of 25 to 100 m.

The analysis of biological and sampler materials was accomplished by two methods:

Biological samples -----acidic digestion
(leaves, lichens,
animal organs)

Extractions -----aqueous extraction for anions
(cheesecloth bags) -----acidic (0.1N HNO₃) for cations

Approximately 50% of the data from these studies are available and suggest many interesting biogeochemical relationships. The cheesecloth bags and lichens complex cooling tower drift components, especially boron, rather effectively. Comparisons with other types of mechanical collectors such as hi-volume air samplers will be made. The cheesecloth samplers also absorb anions such as sulphur and chlorides, and nitrate-nitrites. The sulphur is a known cooling tower emission but the other anions collected by these samplers require further study, and comparison with analyses of the cooling tower water.

In the aqueous extraction of the cheesecloth bags, from 60-80% of the boron was released in 4-8 hours but 0.1N HNO₃ obtains essentially all of the boron as well as metals and other cations complexed by the bag. Maximum concentrations of boron are seen on the cheesecloth bags at distances of 150 to 900 feet and drop off with distance from the unit. Boron is detectable at distances of 1/2 mile or more from the units on cheesecloth bags.

Deposition of boron on cheesecloth bags in the vegetation-damaged zone south of Unit 7/8 (P.G.&E. report) in two weeks was 350-600 ppm (µg/g) total

on the bag, and 80-130 ppm ($\mu\text{g/g}$) on barley at the same site.

At Unit 12, the lichens (7.2 g) at the closest location to the towers (200 ft.) complexed a total of 902 μg of boron in two weeks, and showed a bleached, chlorotic coloration, probably from the sulphur emissions. Lichens are quite sensitive to sulphur. The total complexed boron in lichens (7.7 g) at 900 ft. dropped to 86 μg . Barley leaves at these two locations had 52.7 ppm ($\mu\text{g/g}$) and 38.5 ppm ($\mu\text{g/g}$) boron respectively.

All of the phytometer materials and cloth samplers apparently have an affinity for elements in the cooling tower drift. Quantifiable concentrations of F^- , Cl^- , PO_3 , NO_3 , SO_4 , and Br were found on the cheesecloth bags extracted with distilled water.

Organs of mammals contain easily detected concentrations of boron and arsenic. These data are being studied and suggest intake in food materials, primarily seeds and plant parts in these species of rodents. GI tract concentrations of boron are in the range of 4.0 to 137 ppm in a sample of animals from the Unit 12 drift area. No strong correlations with other normal physiological constituents in the organs have been seen but relationships between boron, calcium, and phosphorus have been observed.

A search of the literature on boron physiology has been made and will be used to interpret the data obtained in this study. The physiology of other cooling tower drift elements is relatively well-known.

A new unit at the Geysers Geothermal Area will become operational late in 1979. This unit is the largest in the geothermal field with an expected output of 140 MWe. This unit has been built in a heavily forested area east of the other units of the field, and presents a unique ecological situation

for interaction of the cooling tower drift with a forest canopy. All other units are in other vegetation types, such as chaparral, and oak woodlands, and do not have the unique meteorological and forest ecological characteristics of the new unit. Cheesecloth bag samplers have been placed in the area of the new unit to document the background pre-operational conditions, and to determine if the geothermal field to the west, and upwind, delivers any drift effluent to the area.

Summary

A.) Air Sampling Program

- Cheesecloth bags
 - Lichen bags
1. Initial series of cheesecloth and lichen bags deployed, exposed for two weeks, and collected.
 2. Analytical procedures developed for anion and cation analysis.
 3. Early results indicate that boron, SO_4 , Cl, and other elements are trapped on cheesecloth bags; high concentrations are seen around Units 12, 7/8, 9/10; Cobb Mountain sampler also had boron on it suggesting that effluent from Unit 7/8 may leave Little Sulphur Creek Valley.
 4. Highest boron concentrations were seen in vegetation-kill zone at Unit 7/8.
 5. Cheesecloth and lichen bag analyses will be completed by September 10, 1979.

B.) Vegetation Sampling

1. A variety of species were sampled around Units 12, 7/8, 9/10, and Unit 15 (pre- and post-operational).
2. Elevated boron concentrations were found adjacent to all units sampled with lowest concentrations at Unit 15.
3. Grass pot samples were collected.

C.) Animal Population Sampling

1. Four species of small rodents were sampled in the vicinity of Units 12, 7/8, and 9/10.
2. Kidney, liver, brain, GI tract, muscle were excised, freeze-dried, ground, and digested in acid.
3. Boron and arsenic were found in livers and kidneys of most animals. Analyses will be finished by September 1, 1979.

D.) Future Plans

1. Continued retrieval of cheesecloth and lichen bags at sites where multiple units were fielded.
2. Expansion of air sampling sites westward to obtain adequate baseline; and to area around Unit 18 (at P.G.&E. request).
3. Obtain animal sample in control area near Healdsburg and foothills.
4. Develop a program of collection efficiency studies of cheesecloth bag under controlled meteorological conditions.
5. Field a small series of rainfall collectors at Unit 12 to evaluate wet deposition of drift components for ecological and hydrological program.
6. Extend leaf sampling network if time permits.
7. Reports planned:
 - a.) Air sampling at geothermal power stations with passive samplers.
 - b.) Trace elements in small mammals at geothermal power plants.
 - c.) Trace elements in vegetation adjacent to geothermal power plants.
8. Evaluate other materials for passive samplers to be used at various kinds of power plants.

OCTOPUS COMMUNIQUE

No. 1482

COMPUTATION DEPARTMENT

06 December 1979

To: All ELF Users
From: Stan Solbeck
Subject: Removal of ELF from Public Files

Recent changes in storage media and how they may be accessed have greatly diminished the usefulness of utility routine ELF. For this reason, we are making plans to remove ELF from public files.

ELF performs a few functions not performed by XPORT. Within a few months, XPORT and ENTERPRISE will be modified so as to provide: (1) the ability to generate a list of directory properties similar to that returned by the ELF DPR command and (2) the ability to read all or a subset of files from another machine. Once these features are available in XPORT, it is anticipated that ELF will be removed from public.

I am setting a target date of May 1, 1980 for the removal of ELF from public. This will allow current ELF users time to make any code conversions required to run XPORT. The above-mentioned XPORT features should be available at least one month prior to the removal of ELF from public. If they are not, the target date will be adjusted accordingly.

If you are aware of ELF features not available in XPORT that are critical to your use of the computer facility, please contact either Neale Smith (x2-0822) or myself. All inquiries regarding differences between ELF and XPORT should be directed to Neale Smith.

Stan Solbeck
SIG/USD
Ext. 2-3761

SKM